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DENDROKRONOLOŠKO DATIRANJE OBJEKTOV V SLOVENIJI

DENDROCHRONOLOGICAL DATING OF WOODEN OBJECTS IN SLOVENIA

Izvleček

Predstavljene so osnove dendrokronološkega datiranja in primeri uspešnih, delno uspešnih in neuspešnih datiranj lesenih konstrukcij in stropov v Sloveniji. Dendrokronološka analiza se začne z odvzemom, pripravo in deteminacijo vzorcev. Pri datiranju se srečujemo s številnimi težavami, kot so problematične drevesne vrste, premajhno število branik in nezmožnost odčitavanja branik. Macesnovina, jelovina, smrekovina in hrastovina spadajo med lesne vrste, s katerimi se pri analizah največkrat srečamo. Z datiranjem macesnovine in jelovine skoraj ni težav, veliko pa jih je pri datiranju smrekovine in hrastovine.

Dendrokronologija in datiranje

Dendrokronološko datiranje je edina absolutna metoda določevanja starosti lesenih objektov na svetu (npr. Stokes in Smiley, 1996). Datiranje je postopek, s katerim določimo branikam leto nastanka (slika 2). Za korektno datiranje morajo biti izpolnjeni naslednji predpogoji:

- Na vzorcu mora biti dovolj veliko število branik. Metode datiranja temeljijo na statističnih testih in vizualnih primerjavah, zato mora imeti vzorec vsaj 40 branik, da ga lahko datiramo. Pri vizualnih primerjavah primerjamo predvsem podobnost rastnih ritmov, pri statističnih pa spremembe vrednosti širin branik. Zato je datiranje majhnih predmetov nemogoče, če vzorec nima dovolj branik ali če le-te niso dovolj vidne.
- Branike morajo biti jasno vidne. Predpogoj za uspešno merjenje je dobra vidnost branik. To dosežemo z ustrezno pripravo površine za merjenje. Če površine ne moremo ustrezno pripraviti, so rezultati merjenja nezanesljivi in sinhronizacija ter kasnejše datiranje ni sta možna. Podobno velja za dragocene predmete, kjer zaradi vrednosti ali želje lastnika predmeta branik ne moremo narediti vidnih, ne da bi pri tem poškodovali predmet (primer Semeniške knjižnice v Ljubljani).

Abstract

We present the basics of dendrochronological dating together with examples of successful, less successful, and unsuccessful dating of roof constructions and ceilings in Slovenia. Each analysis starts with coring, sample preparation, and wood determination. It is not always possible to date a sample, because we are faced with many obstacles as problematic growth patterns, unsuitable tree species, too few tree-rings, or sometimes the high value of the analysed object which may not be damaged by sampling. The larch, spruce, silver fir and oak are most frequently investigated. Dating of larch and silver fir is often possible but we face many problems with the spruce and oak.

Dating in dendrochronology

Dendrochronological dating is the only absolute method to determine the age of wooden objects (see Stokes & Smiley 1996). Dating is the process of determining the year of formation of a tree-ring (Figure 2). For correct dating the following precautions must be taken into account:

- The sample must have enough tree-rings. All dating methods are based on statistical tests and visual comparisons of samples, therefore each sample must have at least 40 tree-rings. We compare tree-rings patterns visually, while in statistical tests we compare changes in values. For this reason dating of small object having insufficient number of tree-rings is not possible.
- Tree-rings must be visible. Good distinctness of tree-rings is necessary for successful measuring. It is achieved by using different preparation techniques. If the surface is not well prepared, successful measuring, synchronisation and dating are not possible. The same is valid for valuable objects - if we cannot see the tree-rings the dendrochronological analysis and dating is impossible (example of the Seminary library in Ljubljana).
- Material must be sufficiently preserved.

- Material mora biti dovolj ohranjen. Material, ki ga dobimo v analizo, mora biti ohranjen do take mere, da so branike še vidne in da je mogoče les pripraviti za merjenje. V našem laboratoriju imamo izkušnje z mokrim lesom s kolišč, z lesom iz ostrešij, ki so ga napadli razni lesni škodljivci, in z zoglenelim lesom.
- Material ne sme izvirati iz tropskih in subtropskih krajev. Les, ki izvira iz tropskih krajev, po pravilu ni primeren za dendrokronološko delo, ker drevje v tropih in subtropih praviloma nima letnega rastnega ritma, ampak se ravna po sušnih in deževnih dobah in po notranjih fiziološko pogojenih mehanizmih.
- Na razpolago mora biti ustrezna referenčna kronologija ali možnost heterokonekcije. Datiranje tudi ni mogoče, če za lesno vrsto, iz katere je predmet narejen, nimamo ustrezne kronologije (npr. topolovina, lipovina) in če heterokonekcija, skladnost kronologije s tistimi iz drugih regij, ni mogoča.

Postopek dela

Vsaka datacija se najprej začne z dogovorom in ogledom objekta za dendrokronološko analizo. Sledi odzvem vzorcev, ki je prilagojen predmetu ali konstrukciji, katero želimo analizirati. Če gre za stoječo strešno ali stropno konstrukcijo, ki naj bi po odvzemu vzorcev še naprej opravljala svojo funkcijo, potem opravimo odvzem vzorcev s posebnimi votlimi svedri. Pri nas uporabljamo tiste, ki jih je razvil danski dendrokronolog Thomas Bartholin. Po takem odvzemu se mehanske lastnosti konstrukcije ne spremenijo, zato lahko le-ta še naprej opravlja svojo funkcijo. V primeru, da gre za prenovo ostrešja in se bo staro ostrešje odstranilo, vzorce odvzamemo z motorno žago, ko se strešna konstrukcija zamenjuje. Kadar gre za dragocene poslikane predmete, tehniko odvzema vzorcev popolnoma prilagodimo možnostim. V skrajnem primeru s finim brusnim papirjem pobrusimo zakriti rob predmeta in ročno opravimo meritve (npr. poslikan strop cerkvice v Gostečah). Možnosti za odvzem vzorcev oz. za opravljanje meritev na mestu je mnogo, zato smo dendrokronologi sposobni pridobiti meritve tudi na zelo dragocenih predmetih (npr. Stradivarijeve violine, slike na lesu itd.).

Koraki, ki sledijo odvzemu vzorcev, so tesno povezani z dobro opremljenim dendrokronološkim in anatomskim labo-ratorijem. V anatomskem laboratoriju se opravi makroskopska in mikroskopska determinacija lesne

Analysed material should be in acceptable condition for surface preparation. If we cannot prepare the surface, all measurements are questionable. Our laboratory has much experience with wet wood from the Ljubljana Moor, old wood from roof constructions, as well as those which are attacked by insects or partly carbonised.

- Wood from tropical and subtropical trees. Wood originating from tropical and subtropical regions is usually not suitable for dendrochronological analysis since trees in those regions usually do not build rings in regular annual intervals.
- A reference chronology or possibility of heteroconnection for the studied wood species is needed. Dating of wood species, such as poplar, lime or beech is usually impossible because there are no reference chronologies available. In some cases there exists possibility of heteroconnection, i.e. cross-dating of chronologies with those from different regions.

Sampling procedure

Each analysis of an object starts with its inspection and examination of possibilities for sampling. Sampling is always done in accordance with possibilities and limitations of the studied object. If the age of a roof construction should be determined, we use borers developed by the Danish dendrochronologist Thomas Bartholin. After coring, the roof construction remains intact with unchanged mechanical properties. If the roof construction is being removed, we take samples with a chain saw. In the case of a valuable painted object which may not be damaged, we measure tree-ring widths by a hand lens. In such case, the hidden surface of the object is lightly sanded - such technique was used on the painted ceiling of the church in Gosteče.

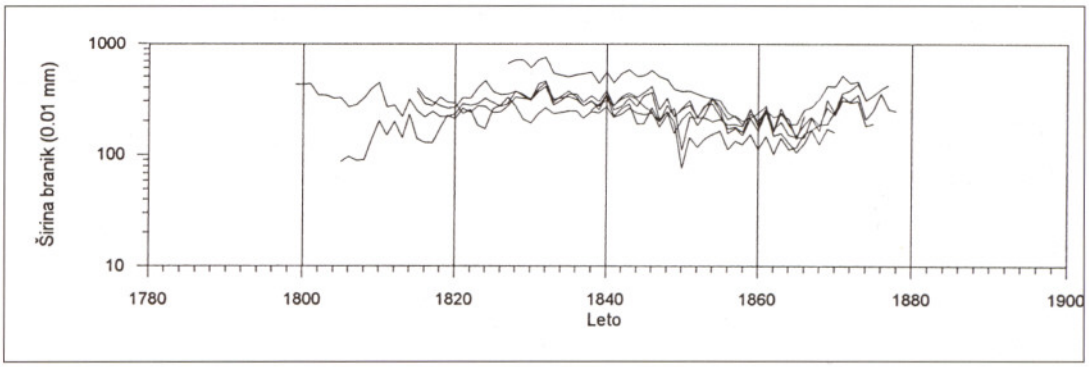
There are many possibilities for measurements even in the case of very precious objects (e.g. paintings on wooden panels, Stradivari violins, etc.).

The steps which follow sampling are tightly connected to well equipped anatomical and dendrochronological laboratories and trained and skilled staff. In the anatomical laboratory macroscopic and microscopic determination of wood species is done, while in the dendrochronological laboratory, measurements, synchronisation and dating are performed.

At the end of the analysis, even in unsuccessful cases, the report is written and all steps of the analysis are described as well as the results of dating are presented. If dating was not

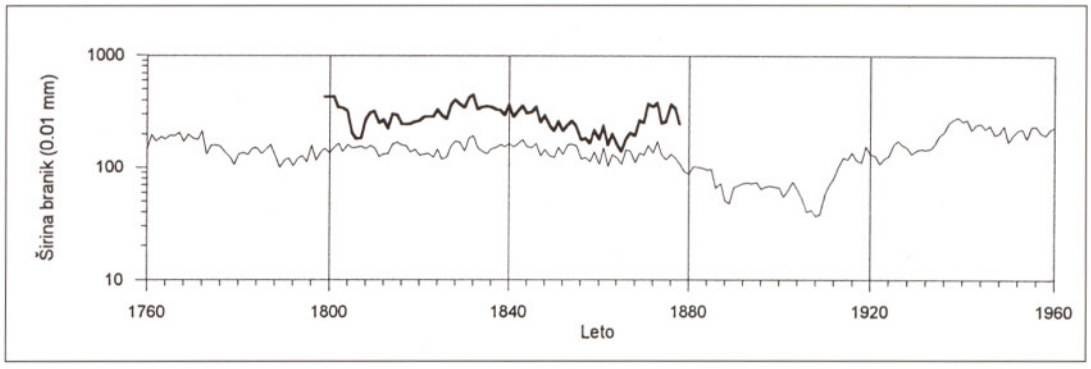
Slika 1: Zaporedja širin branik v sinhroniziranem položaju.

Figure 1.- Tree-ring series in synchronised position.



Slika 2: Datiranje kronologije objekta (debela črta) z referenčno kronologijo (tanka črta).

Figure 2.- Dating of a floating chronology (bold line) with the reference one (thin line).



vrste, v dendrokronološkem laboratoriju pa se opravijo meritve, sinhronizacija in datacija vzorcev.

Končani analizi sledi poročilo o letu nastanka analiziranega objekta. Poročilo napišemo tudi v primeru, ko datiranje ni bilo uspešno. V poročilu je opisan postopek analize in dobljeni rezultati. Če datacija ni bila mogoča, so opisani razlogi za to. Vsi vzorci, meritve in poročila se hranijo v našem arhivu. Kadar datiranje objekta trenutno ni bilo mogoče, je še vedno možnost, da ga bomo datirali takrat, ko bomo z delom toliko napredovali, da bomo ustrezno kronologijo podaljšali v preteklost (primer starega kozolca v vasi Grebenje). Pomembno pa je tudi, da vsak objekt, ki ga dobimo v naš laboratorij, predstavlja delček v mozaiku izgradnje dolgih referenčnih kronologij.

Problematične drevesne vrste

Južno od Alp postanejo nekatere sicer "krotke" drevesne vrste zelo nepredvidljive. Mednje spadajo predvsem vsi bori, smreka in hrasti. Z bori in hrasti imajo države severno od Alp zelo dobre izkušnje in ocenjujejo, da imajo velik dendrokronološki potencial. Bori in hrasti imajo severno od Alp umirjeno, razmeroma počasno rast, ki se dobro odziva na zunanje, predvsem klimatske dražljaje. Zaradi tega je npr. Nemcem, Francozom, Fincem in Poljakom uspelo sestaviti dolge borove in hrastove kronologije. Nemška hrastova kronologija je dolga preko 10.000 let, finska borova pa preko 8000 let.

Glede smreke v Evropi ugotavljamo, da je

successful, possible reasons for this are described as there is still the possibility of future dating. All measurements become a part of our huge database which is constantly being improved, giving us the possibility for dating objects which were not datable before (e. g. old hayloft in the village Grebenje near Velike Lašče). We must also stress that each analysis contributs to the construction of long-term chronologies for different tree species.

Problematic wood species

The radial increment of some tree species known all over Europe becomes very unpredictable south of the Alps. In this group are all oaks, spruce and some species from the genus *Pinus* (the black and Scots pine). Dendrochronological laboratories north of the Alps have achieved very good results with oaks and pines and it is generally accepted that this species have a high dendrochronological potential. Pines and oaks north of the Alps have highly climate dependant growth. Thus it was among others possible to construct an over 10 000 years long German oak chronology and an 8 000 years long Finnish Scots pine one. Spruce is in comparison to the pine and oak a very "complicated" tree species, one of the most complicated tree-species for dendrochronology in Europe. So far, we know that we need many different local chronologies for dating spruce objects. In the future we should develop at least two spruce chronologies for Slovenia, one for low elevations where the spruce has a high radial

Vzorec hrastovine iz ostrešja. Les ima razločne branike, vendar jih je premalo za dendrokronološko datiranje. Vidni so tudi rovi insektov.

Oak sample from a roof construction. The tree-rings are visible but their number is too low for dendrochronological dating. The wood contains insect holes.

izjemno problematična in da za pravilno datiranje skoraj vedno potrebujemo več smrekovih kronologij za različna rastišča. Enake so ugotovitve tudi za smreko v Sloveniji. Najmanj, kar potrebujemo, sta zanesljivi kronologiji za nižinsko in višinsko smreko, ki se znatno razlikujeta po povprečni širini branik - nižinska ima širše, višinska pa ožje branike.

Za razliko od velikih uspehov, ki jih imajo z bori in hrastom kolegi severno od Alp, do sedaj še nobenemu laboratoriju južno od Alp ni uspelo sestaviti daljše hrastove ali borove kronologije (Martinelli et al., 1992).

Razlogov za to je več, med bistvene pa zagotovo spadajo popolnoma drugačne rastne značilnosti borov in hrastov ter naravne danosti rastišč južno od Alp.

Z ekološkega vidika sta v Sloveniji hrasta dob (Quercus robur) in graden (Quercus petraea) drevesa gričev in ravnin. Predvsem dob raste tam, kjer je dovolj vode, predvsem talnice in dobro prirašča - širina branike je 0,5 cm in več. Graden pa raste nekoliko više na gričih in v primerjavi z dobom nekoliko slabše prirašča. Lesa doba in gradna anatomsko ne moremo ločiti, zato v dendrokronološki praksi govorimo o lesu obeh vrst kot o hrastovini. Oba hrasta, predvsem pa dob, dosegata zavidljive razsežnosti ob razmeroma nizkih starostih. Zato ima

increment and one for slow grown spruce from high elevations.

So far there has been nearly no success with dendrochronology of oaks and pines in the regions south of the Alps (Martinelli et al. 1992). There are many reasons for this, the most important could be site and ecological differences in comparison to regions north of the Alps.

From the ecological point of view the pedunculate (*Quercus robur*) and the sessile oak (*Quercus petraea*) are trees of hills and lowlands. The pedunculate oak grows in environments with high level of ground water. The average tree-ring widths of this species in our region are 8 mm or more. On the other hand, the sessile oak from the hill region grows slightly more slowly - the average tree-ring width is around 5 mm. Anatomically, there are no differences between the woods of both species, therefore we usually speak about oak wood. South of the Alps both species grow very well, achieving respectable dimensions in a relatively short time. Oak wood used in constructions usually has few tree-rings, and a high percentage of samples is not suitable for dendro-chronological analyses. The construction of long oak chronologies south of the Alps is expected to be a long process with unpredictable end.

hrastovina, uporabljena v konstrukcijah, majhno število širokih branik. Večina vzorcev zaradi majhnega števila branik ne ustreza standardom za dendrokronološko analizo. Iz istega razloga je tudi sestavljanje daljše in uporabne kronologije izjemno dolgotrajen proces z nepredvidljivim rezultatom.

Pri borih, v mislih imamo predvsem črni (Pinus nigra) in rdeči bor (Pinus sylvestris), je nekoliko drugače. Naravnih rastišč črnega in rdečega bora v Sloveniji praktično ni. Prava naravna rastišča so majhna po površini in se pojavljajo le sporadično v zares izjemnih rastnih razmerah (npr. črni bor na Krempi na Kočevskem ali rdeči bor na kislih rastiščih v okolici Ljubljane). Če se pojavljajo, so to razni degradacijski stadiji nižinskih rastišč hrasta in bukve. Rdeči bori, ki jih najdemo na degradirinanih hrastovih in bukovih rastiščih v okolici Ljubljane (steljniki za Šmarno goro) imajo tako specifične prirastne ritme, da si tudi drevesa znotraj raziskovalnih ploskev po prirastnih ritmih niso podobna. Na srečo je bila borovina v preteklosti v Sloveniji le redko uporabljena za konstrukcije, zato trenutno ni povpraševanja po borovih kronologijah za datiranje. Kronologije borov so pomembne predvsem za dendroekološke in dendroklimatološke raziskave.

Med problematične drevesne vrste spadajo še topoli, lipe, dren, različni predstavniki iz roda Sorbus (npr. omare za orožje so pogosto iz skorša ali breka), pa tudi bukev in jesen.

Praktični primeri

Uspešne datacije

Cerkev Sv. Jurija v Piranu

Restavratorje in konzervatorje cerkve sv. Jurija v Piranu iz RRC v Ljubljani je zanimalo, kako veliko je bilo ostrešje cerkve v posameznih obdobjih in iz katerih obdobij so obstoječi deli ostrešja. Če bi dobili te informacije, bi lahko z ustreznimi metodami rekonstruirali velikost cerkvenega ostrešja v posameznih obdobjih in tako posredno sklepali na velikost cerkve. Ob prvem ogledu ostrešja smo najprej vzeli vzorčke lesa za lesno anatomske analize in določili lesno vrsto. Ugotovili smo, da je bila skoraj vsa strešna konstrukcija iz macesnovine, ki je bila na nekaterih mestih ojačana z jelovino, en tram pa je bil iz brestovine. Skupno smo vzeli 98 vzorcev in določili tri gradbene faze, ki so se končale: prva leta 1262 (macesnovina), druga 1594 (macesnovina) in tretja leta 1878 (jelovina). (Glej Levanič et al., 1997.)

Kasjakova domačija na Pohorju

Dendrokronološka analiza Kasjakove domačije na Pohorju je bil šolski primer uspešnega datiranja in podaljševanja

The natural area of the genus *Pinus* - with the black (*P. nigra*) and Scots pine (*P. sylvestris*) is relatively small in Slovenia. Their natural stands are small and dispersed (e.g. the black pine stand south of Kočevje, Krempa, or the Scots pine stands on acidic soils in the surroundings of Ljubljana). Non-natural stands are usually various degradation stadiums with very specific growth conditions. Fortunately, pine wood was rarely used for construction and therefore at the moment there is no need for long pine chronologies in Slovenia.

Other problematic tree species are poplars (*Populus* sp.), limes (*Tilia* sp.), different species from the genus *Sorbus* - often used for furniture such as trophy cabinets or gun racks and even the beech (*Fagus sylvatica*) and ash (*Fraxinus* sp.)

Practical examples

Successful dating

St. George's church in Piran

Restorers and conservators of St. George's church in Piran were interested how big the roof construction of the church was at different times and which were the most important building phases of the roof and the church itself. If we can reconstruct the size of the roof construction at different time periods, we can also reconstruct the size of the church itself. First, the wood anatomical analysis showed that the roof construction was made of larch with silver fir supporting elements. Altogether, we took 98 samples and dated three construction phases which ended in 1262 (larch), 1594 (larch), and 1878 (silver fir) - (see Levanič et al. 1997).

Kasjak's old house and barn on Pohorje

Dendrochronological analysis of Kasjak's old house and barn was an example of successful dendrochronological dating. The owner was interested to know how old his farm house and barn were and if the carved inscription "1888" could be confirmed. Our interest was to make a local silver fir chronology for the Pohorje region and to compare it with already existing Dinaric silver fir chronology. First, we took samples from the standing trees and then from both objects. It was confirmed that the old Kasjak's house was built after 1852 and the barn after 1887. Chronologies from both objects and from standing trees are now a part of the Slovene regional silver fir chronology (Levanič & Čufar 1998).

Old military houses at the Soča Front

We dated old military objects from the World War I on Soča Front to build a long Slovene larch chronology. Most samples were cross-dated and the objects were dated into year

kronologij. Lastnika je zanimalo, koliko so stari posamezni objekti Kasjakove domačije in ali vrezane letnice držijo, mi pa smo želeli narediti daljšo kronologijo za področje Pohorja in jo primerjati z obstoječo dinarsko jelovo kronologijo. Hoteli smo tudi združiti obe jelovi kronologiji in narediti regionalno slovensko jelovo kronologijo. Najprej smo odvzeli vzorce iz rastočih jelk in nato še iz objektov. V vseh primerih je šlo za jelovino. Rezultati so bili naslednji: Kasjakova stara hiša je bila postavljena po letu 1852, skedenj pa po letu 1887. Kronologije teh objektov in kronologija rastočih dreves so tudi sestavni del pohorske jelove kronologije (Levanič in Čufar 1998).

Vojaški objekti na območju soške fronte

Z datacijo macesnovine iz vojaških objektov na Soški fronti (Komen z okolico) - datirani so bili v leto 1849 - in s pomočjo vzorcev iz rastočih macesnov smo želeli vzpostaviti most med macesnovimi kronologijami iz cerkve sv. Jurija v Piranu in sedanjostjo ter tako dobiti referenčno macesnovo kronologijo za območje Slovenije (Trebušak, 1998). Uspešno delo na obeh projektih in sodelovanje z Olivio Pignatelli iz laboratorija DENDRODATA v Veroni je omogočilo, da smo sestavili 1242 let dolgo macesnovo kronologijo za obdobje 756 do 1997, ki omogoča datiranje macesnovine ne samo v Sloveniji, temveč tudi v severni Italiji.

Kozolec v vasi Grebenje pri Velikih Laščah

Kozolec v vasi Grebenje je dober primer t.i. "naknadnega datiranja". Po ustnih virih naj bi bil postavljen leta 1776, vendar materialnih dokazov za to ni bilo. Notranja konstrukcija kozolca je bila narejena iz jelovine, nosilna pa iz hrastovine. Ko smo prvič analizirali omenjeni kozolec, dobljenih kronologij nismo mogli datirati, ker še nismo imeli ustrezne jelove kronologije. Ko je naše delo na jelki dovolj napredovalo in smo sestavili daljšo jelovo kronologijo, smo ponovno poskusili datirati kozolec. Izkazalo se je, da je večina vzorcev iz leta 1751, kar potrjuje ustne vire. Primer tega kozolca nam pove, da četudi datacija v tem trenutku ni mogoča, je lahko možna kasneje, ko bo naša baza kronologij izpopolnjena.

Delno uspešne datacije

Minoritski samostan sv. Frančiška v Piranu

Analizo lesenih delov stropne in strešne konstrukcije smo opravili na željo restavratorke, konzervatorke in slikarke Mire Ličen-Krmpotič. Del materiala je bil že odvzet iz stropa in ostrešja ter pripravljen na kupu. Iz tega materiala smo odvzeli 19 vzorcev, del vzorcev pa smo z vrtanjem odvzeli iz stropne konstrukcije. Od lesnih vrst sta bili prisotni

1849. To prolong the chronology to the present, samples from standing trees were used (Trebušak 1998). Using this chronology we connected the previously constructed larch chronology of the St. George's church in Piran to the present. Based on this chronologies and those of Olivia Pignatelli from the DENDRODATA laboratory in Verona, Italy, we constructed a 1242 years long larch chronology spanning the period of 756 to 1997.

The hayloft in the village Grebenje near Velike Lašče

The hayloft in the village Grebenje near Velike Lašče is a good example of "subsequent dating". According to oral sources it was supposedly built around 1776, but there was no proof of this. The inner part of the construction was made of silver fir, while the main construction was made of broadleaf species. After sampling we could not immediately date the chronologies. One year later, when the Slovenian silver fir chronology was improved we could successfully date it. Our dating was 1751, which confirmed the verbal source. This shows that even if we cannot date the object now, we can expect to date it later when the chronologies are improved and prolonged to the past.

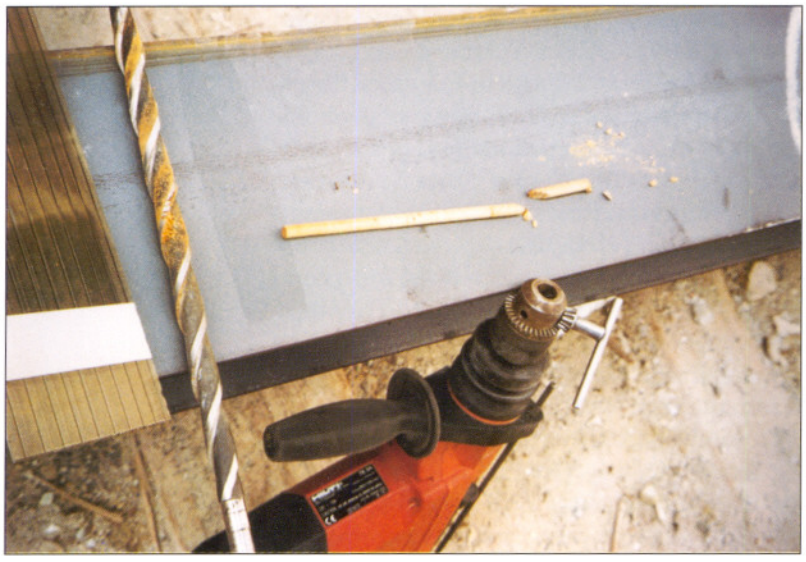
Partially successful dating

Minorite monastery of St. Francis in Piran

Analyses of the wooden parts of the roof construction and ceiling were done in co-operation with Mrs. Mira Ličen-Krmpotič who is responsible for restoration and conservation works in the monastery. Part of the material,

Odvzem vzorcev iz ostrešja cerkve sv. Jurija v Piranu.

Taking cores from a roof construction of the St. George's church in Piran.



Vrtalni stroj z votlim svedrom in izvrtek lesa.
The borer and the core.

jelovina in smrekovina. Datacija je bila le delno uspešna, saj smo imeli velike težave z vzorci, ki jih nismo odvzeli sami in jih praktično nismo mogli datirati. Vzorce, ki smo jih z vrtanjem odvzeli iz stropne konstrukcije, smo uspeli datirati. Določili smo dve pomembnejši gradbeni fazi, in sicer v letih 1307 in 1762. Delni neuspeh pripisujemo predvsem neznanemu poreklu materiala na vnaprej pripravljenem kupu "vzorcev". Zato opozarjamo, da je prisotnost dendrokronologa pri odvzemu vzorcev nujna, še preden se začno večja prenovitvena ali obnovitvena dela in konstrukcijo porušijo.

Pretorska palača v Kopru

Pretorska palača v Kopru je primer zelo pestre arhitekture z menjavajočimi se stilskimi značilnostmi. V zgodovini je bila večkrat predelovana in pri predelavah so uporabljali različne lesne vrste. Tako najdemo na stropu poslikane hrastove stropne deske, tramiče s

Kozolec v vasi Grebenje pri velikih Laščah. Jelovina iz kozolca je bila datirana v leto 1751.
The hayloft in Grebenje near Velike Lašče. The silver-fir from the inner part of the construction was dated 1751.

19 samples had been collected by the restorers, the others were taken from the ceiling by coring. We determined silver fir and spruce wood. Dating was only partly successful: we could not date non-systematically collected samples, but we could date those taken by coring. We found two main construction phases, one dated 1307 and the other 1762. The main reason for only partial success was non-systematic sampling. It was shown that the presence of a dendrochronologist at the time of sampling and consultations with him prior to sampling would help a lot.

Praetor's palace in Koper

Praetor's palace in Koper is an example of a very rich and diverse architecture. It was often rebuilt and renewed, therefore we found different wood species in the roof construction and the ceilings: The silver fir and spruce were used in the roof construction. Painted ceilings were made of oak, and various decorative wooden elements were made of larch. During the dendrochronological analysis we were faced with many problems, such as only 20-30 tree-rings in the oak and a very specific growth pattern of silver fir and spruce. Synchronisation and subsequent dating were impossible for oak and only partly successful for silver fir. We could not date the spruce either. On the other hand, we successfully dated the larch decorative elements to 1262. Altogether the dating was only partially successful.

Bassegio's palace in Koper

Bassegio's palace was build in the gothic and renewed in baroque period. We took 50 cores from two construction phases which were made of silver fir and spruce. The curves of both species cross-dated well, but due to very short chronologies we could not precisely date them.

Parochial church of St. Vid in Šentvid near Ljubljana

In the church of St. Vid in Šentvid we analysed the oak pew to prolong the existing oak chronology of the Ljubljana region. The church pews were according to a carved inscription made in 1924. The tree-ring widths were measured non-destructively by using the measuring lens. The results of synchronisation were promising and the chronology could be visually dated on the oak chronology, but statistical values were not significant to confirm the dating.

Ruins of the Gorenji Mokronog Castle, Dolenjska

According to the sources the Gorenji Mokronog Castle in the Dolenjska region had been burned down in the 16th century.

pletenicami iz macesnovine, ter stropne nosilce in strešno konstrukcijo iz jelovine in smrekovine. Pri dendrokronološki analizi pretorske palače smo se srečali z vrsto težav. Hrastovine zaradi premajhnega števila branik (med 20 in 30) ni bilo mogoče datirati. Smrekovina in jelovina sta imeli zelo specifičen rastni ritem, zato že sinhronizacija meritev ni bila mogoča. Nekoliko uspešnejši smo bili le pri datiranju macesnovih tramičev s pletenico, ki smo jih uspeli datirati v leto 1262. V splošnem pa je bilo datiranje lesa v pretorski palači neuspešno.

Palača Bassegio v Kopru

Palača Bassegio v Kopru je zanimiva za dendrokronološke analize zato, ker je bila zgrajena v obdobju gotike in prenavljana v baroku. Vzeli smo več izvrtkov iz domnevno različnih gradbenih faz. Od lesnih vrst sta bili prisotni smrekovina in jelovina. Rezultati datiranj so bili nezanesljivi, zato nismo mogli podati datumov dograditve in prenove stavbe. Bistvo težav je bilo predvsem v premajhnem številu branik v vzorcih, zato statistični rezultati datiranja niso bili značilni.

Cerkev sv. Vida v Šentvidu

V cerkvi sv. Vida v Šentvidu smo poskušali analizirati hrastove klopi, ki so bile po virih izdelane leta 1924 (vrezan datum). Ker noben drug način merjenja širin branik ni bil mogoč, smo morali širine branik odčitati ročno s pomočjo merilne lupe. Rezultati merjenja so bili ugodni, kronologije je bilo mogoče lepo sinhronizirati in so se vizualno dobro ujemale s standardno hrastovo kronologijo. Nismo pa uspeli vizualnega rezultata potrditi s statističnimi testi, zato menimo, da je datiranje le delno uspelo.

Požganina gradu Gorenji Mokronog na Dolenjskem

Grad Gorenji Mokronog na Dolenjskem je bil po virih požgan v prvi polovici 16. stoletja. Ker ta podatek ni bil zanesljiv, je arheologe iz ZRC SAZU zanimalo, ali bi ga bilo mogoče natančneje preveriti. Iz nabranih vzorcev zoglenelih tramov smo s posebnimi preparativnimi tehnikami dobili šest uporabnih vzorcev. Anatomska analiza lesa je pokazala, da gre za pravi kostanj (Castanea sativa). Vzorci sami po sebi zaradi premajhnega števila branik niso ustrezali dendrokronološkim kriterijem za datiranje, vendar smo pri sinhronizaciji dobili 57 let dolgo kronologijo, ki je ustrezala kriterijem. Ker kronologije za pravi kostanj nimamo, smo skušali to vzorce datirati z južno nemško jelovo kronologijo (t.i. hetero-konekcija). Iz ekologije jelke in pravega kostanja je znano, da ti dve drevesni vrsti na kislih rastiščih

Odvzem vzorcev lesa, ki je odstranjen iz konstrukcije.

Sampling timber which has been removed from a construction.

This was the only available information. Archaeologists from the Research Centre of the Slovenian Academy of Science and Arts were interested to know a more precise dating. We analysed remnants of wood found during the excavation works. All samples were carbonised and were in a very poor condition. Anatomical analyses showed that the wood was chestnut (*Castanea sativa*). The wood was surfaced by using a special wet sanding technique. Although the individual samples had only

Merjenje širin branik s pomočjo lupe.

Measuring tree-ring widths by using the lens.

lahko rasteta tudi skupaj, zato bi bila lahko heterokonekcija možna. Rezutat datiranja je zaradi nekoliko kratke kronologije nezanesljiv, vendar smo kljub vsemu vizualno in statistično ugotovili, da je bil grad požgan po letu 1515. Bolj natančnega datuma zaradi močno poškodovanih vzorcev nismo mogli podati. Če upoštevamo dinamiko rasti pravega kostanja in poškodovanost periferije vzorcev zaradi požara, vendarle lahko sklepamo, da je pravi datum požiga nekje med leti 1540 in 1550.

Neuspešne datacije

Poslikan kasetiran strop cerkvice v Mačah pri Preddvoru

Pri restavratorsko-konzervatorskih delih v cerkvi v Mačah pri Preddvoru so sodelavci RRC Ljubljana (Ivan Bogovčič) obnavljali poslikan, kasetiran strop iz smrekovine iz 17. stoletja. Strop je bil datiran v leto 1646 in zato smo v sodelovanju z restavratorji RRC Ljubljana odvzeli vzorce, da bi oblikovali plavajoče smrekove kronologije in morebitne potrditve pisane letnice stropa. Vzorce smo izmerili in sestavili kronologijo, dolgo 56 let. Tako kratke kronologije nismo mogli datirati z nobeno znano slovensko ali tujo smrekovo kronologijo. Vendar upamo, da bo mogoče dobljene kronologije datirati z nastajajočo slovensko smrekovo kronologijo.

Poslikan strop cerkve v Gostečah pri Škofji Loki

Problem analize poslikanega stropa gotske cerkvice iz 16. stoletja (posvečena leta 1515) v Gostečah pri Škofji Loki je bil ta, da so v cerkvi našli dva stropa, enega nad drugim. V RRC Ljubljana so se odločili za restavracijo gotskega stropa in nam omogočili tudi dendrokronološke meritve. Strop je bil sestavljen iz smrekovih desk, ki so se tesno stikale. Zaradi tega smo morali pri tem stropu prvič uporabiti ročno tehniko merjenja, ker drug način odvzema vzorcev ni bil mogoč. Dobljena kronologija sicer ustreza vsem dendrokronološkim standardom, vendar je nismo mogli datirati. Menimo, da bomo kronologijo iz cerkvice v Gostečah lahko datirali z nastajajočo slovensko smrekovo kronologijo.

Stara kmečka hiša v Mekotnjaku v Slovenskih Goricah

Zanimiva je bila tudi analiza ostanka stare kmečke hiše iz Mekotnjaka v Slovenskih Goricah. Hiša se je po svojih stilskih značilnostih močno razlikovala od vseh ustaljenih gradbenih stilov za to področje, zato je etnografa dr. Gorazda Makaroviča iz Slovenskega etnografskega muzeja zanimalo,

few tree-rings, they overlapped well and it was possible to construct a 57 years long mean curve which was adequate for dendrochronological dating. Since a chestnut chronology is not available, we tried to heteroconnect it with other chronologies and dated it by using a south German silver fir chronology. The samples were dated 1515, which means that the castle was not burned before this year. By the heavily destructed periphery of the samples and the growing rhythm of the analysed samples we could assume that it was burned down between 1540 and 1550. The statistical values of cross-dating were low but significant.

Unsuccessful dating

Painted church's ceiling in Mače near Preddvor

During the restoration work of the church in Mače near Preddvor, co-ordinated by Mr. Ivan Bogovčič from the Restoration Centre of the Republic Slovenia in Ljubljana, we had the opportunity to take samples from the painted ceiling. Its construction allowed us to take thin sections from the boards without destroying the ceiling plates The ceiling was dated by the inscription to 1646. We constructed a floating chronology which was only 56 years long, but we could not date it with existing spruce chronologies. We hope to date it in the future when the Slovene regional spruce chronology is constructed.

Painted ceiling in the church in Gosteče near Škofja Loka

In a workshop of Restoration Centre of the Republic Slovenia in Ljubljana, the restoration of the old painted ceiling from a 16th century Gothic church was done. The church was consacrated in 1515 which is also the presumable dating of the ceiling. The ceiling was made of tightly connected spruce boards, therefore none of the known destructive methods could be used to take the samples. We made the tree-ring measurements by using the measuring lens and entered the measured data into a computer.

The constructed floating chronology corresponded to all dendrochronological standards, but could not be dated with existing spruce chronologies. We hope to date it in the future.

Old farm house in Mekontjak, Slovenske Gorice

Old farm house in Mekotnjak in Slovenske Gorice was an example of, unfortunately, unsuccessful dating. Due to its architectural style, the house was very different from the others in the area. The ethnologist Dr. Gorazd Makarovič from the Slovene Ethnological

koliko je stara. V analizo nam je dostavil 9 čel desk, ki so bile dobljene z razrezom debelejšega trama, ki je nosil celotno strešno konstrukcijo stare hiše. Anatomska analiza lesa je pokazala, da gre za hrastovino. Sinhronizacija vzorcev je bila dokaj enostavna, kronologije pa ni bilo mogoče datirati, ker je bilo število branik premajhno in rezultat datiranja ni bil zanesljiv.

Museum wanted to know its age. We analysed nine oak boards, which were once a part of a single beam, the main carrier of the whole roof construction. Synchronisation of the samples was easy, however dating was impossible due to insufficient number of tree-rings.

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